Rex Chert

Flow in the Rex Chert member would be affected by the proposed action. The mine pit panels would be excavated through the Rex Chert member (**Figure 4.3-2(b)**). Groundwater flow in the Rex Chert would decrease after mining because water infiltrating through the backfill would preferentially flow in the high-permeability backfill rather than entering the Rex Chert, which has a lower permeability. It is estimated that 2.44 inches/year infiltrates into the Rex Chert member in the pre-mining condition, decreasing to 0.05 inches/year for the Rex Chert below the fully backfilled pit (**Table 4.3-9**) and 1.4 inches/year in the exposed wall of the partially backfilled pit. The total volume of infiltrating water decreases, according to the infiltration predicted by the HELP model. The partitioning of the infiltrating water between alluvium and Rex Chert (pre-mining) and backfill and Rex Chert (after mining) was calculated for a unit area using the Darcy equation, Q=KI. Values used for K and I, along with the calculated Q, are shown in **Table 4.3-7**.

Constituents would leach from the run of mine (ROM) backfill into the underlying chert. Concentrations in the ROM leachate would generally be higher than in the alluvium that overlies the chert before mining (**Table 4.1-1**). However, the infiltration rate through the ROM backfill into the chert would be lower than the pre-mining infiltration rate through the alluvium (**Table 4.3-9**); therefore, the total mass loading would be less than in the pre-mining condition for all COPCs except selenium. Mass loading of selenium would increase by approximately 46 percent (**Table 4.3-10**).

The effect on groundwater quality in the Rex Chert would depend on the concentration and volume of leachate, as well as the concentration and volume of the receiving aquifer. The background water quality in the Rex Chert is discussed in Section 3.3.5

Wells Formation

The Wells Formation outcrops on Rasmussen Ridge, along the axis of the Snowdrift structural anticline. The limestone in the Wells Formation would be exposed in the footwall of the pit panels (**Figure 4.3-1**), and is unsaturated at the elevation of the proposed pit. The lowest elevation of proposed pit floor is 6,740 feet, while the estimated water level in the Wells Formation is 6,340 feet (**Figure 4.3-1**). Groundwater flow in the Wells Formation would not be affected during mining.

After mining, a groundwater mound would occur in the Wells Formation as a result of the increased infiltration in the partially backfilled pit area. The partially backfilled pit would collect surface runoff from the pit walls and upgradient undisturbed ground. This water would infiltrate through the limestone backfill, and would flow vertically through the unsaturated zone below the pit floor to the regional water table. The infiltration rate through the partially backfilled pit was evaluated using the EPA HELP3 model, which predicted 88.45 inches of infiltration per year for partially backfilled zone C3 (Whetstone 2002). The infiltration rates would be lower in fully backfilled zones (A1, A2, B1, B2) and partially backfilled zones C1 and C2 after mining (0.83 inches per year) than before mining (2.7 inches per year) as a result of the efficiency of the engineered cover and surface water diversion structures. Infiltration through the exposed pit

TABLE 4.3-9
POTENTIAL REDUCTION IN RECHARGE TO THE REX CHERT RESULTING FROM THE PROPOSED ACTION

Material	K (ft/day)	I (ft/ft)	$q_{saturated}$ ((ft^3/day)/ft^2)	% of Flow	Infiltration (in/year)	Comments
Recharge to Rex Chert Pre-mining (2.7 inches/yr infiltration)						
Alluvium	0.31	0.342	1.07E-01	9.8%	0.26	Alluvium K value based on geomean of all available hydraulic conductivity tests. Gradient based on 20% contact slope
Rex Chert	0.99	1	9.90E-01	90.2%	2.44	Rex Chert K value based on geomean of hydraulic conductivity tests in Rex Chert at N. Rasmussen Ridge ($3.49x10^{-4}$ cm/sec). Gradient is unit vertical gradient.
Recharge to Rex Chert After Mining (0.83 inches/yr infiltration)						
Backfill	22.85	0.766	1.75E+01	94.4%	0.78	Backfill K value from dual ring permeameter tests ($8.06x10^{-3}$ cm/sec). Gradient based on 47° slope of pit wall.
Rex Chert	0.99	1	9.90E-01	5.6%	0.05	Rex Chert K value based on geomean of hydraulic conductivity tests in Rex Chert at N. Rasmussen Ridge ($3.49x10^{-4}$ cm/sec). Gradient is unit vertical gradient.

Notes: K = hydraulic conductivity
I = hydraulic gradient
q_{sat} = saturated flow rate

TABLE 4.3-10
POTENTIAL IMPACTS TO GROUNDWATER FLOW IN THE REX CHERT RESULTING FROM THE PROPOSED ACTION

Constituent	Alluvium Concentration mg/L	Pre-mining Mass Loading lbs/ft^2	ROM Concentration mg/L	Post-mining Mass Loading lbs/ft2	% Difference
TDS	517	1.35E-03	1,961	9.75E-05	-92.8%
Sulfate	108	2.82E-04	1,283	6.38E-05	-77.4%
Antimony	0.006	1.56E-08	0.007	3.48E-10	-97.8%
Cadmium	0.0004	1.04E-09	0.0116	5.77E-10	-44.7%
Manganese	1.13	2.95E-06	3.28	1.63E-07	-94.5%
Nickel	<0.05	1.30E-07	0.63	3.13E-08	-76.0%
Selenium	0.012	3.13E-08	0.918	4.56E-08	45.9%
Aluminum	<0.1	2.61E-07	0.196	9.72E-09	-96.3%

Notes: mg/L = Milligrams per liter
lbs/ft^2 – pounds per square feet

walls would also decrease after mining because more runoff would occur due to the steep slope and barren surface of the walls. The combination of these factors would result in a 336 percent increase in infiltration recharge to the Wells Formation below the footprint of the pit panels (**Table 4.3-11**). The groundwater flow model indicates that the increased recharge could cause water levels to mound up to 15 feet in the Wells Formation below the partially backfilled pit (**Figure 4.3-5**).

TABLE 4.3-11
POTENTIAL INCREASE IN RECHARGE IN THE WELLS FORMATION RESULTING FROM INCREASED INFILTRATION FROM THE PARTIALLY BACKFILLED PIT

Contributing Areas:		
Area of partially backfilled pit	760,893	Ft^2
Area of exposed walls	3,143,210	Ft^2
Area of fully backfilled pit & C1 & C2	4,939,420	Ft^2
Pre-Mining Condition:		
Pre-mining recharge rate:	2.55	inches/year
Volumetric recharge rate before mining	1,878,985	Ft^3/yr
Post-Mining Condition:		
Post-mining recharge rate for partial backfill:	88.45	inches/year
Post-mining recharge rate for pit wall:	1.4	inches/year
Post-mining recharge rate for full backfill & C1 & C2:	0.83	inches/year
Volumetric recharge rate after mining	6,316,770	Ft^3/yr
Increase in recharge	**336%**	

Water quality in the Wells Formation would also be affected by the Proposed Action. Seepage that infiltrates through the backfill would carry solutes downward through the unsaturated zone into the aquifer.

Calculations of seepage velocity through the 400 feet of unsaturated bedrock between the pit floor and the water table indicate that seepage from the partially backfilled pit portion of the pit under the Proposed Action would reach the water table about 3.3 years after the end of mining. Seepage from the fully backfilled portions of the pit is calculated to reach the water table about 87 years after the end of mining (Whetstone 2002). When they enter the water table, solutes contained in the seepage would mix with groundwater and would be transported north and west by the regional gradient.

Modeled concentrations for COPCs in the regional groundwater aquifer were calculated at the lease boundary for seven observed points (LL1 to LL7) at 100, 200, 300, 400, and 500 years after the end of mining (**Table 4.3-12**). Model observation points LL1, LL2, and LL3 are located west of the A, C, and B panels, respectively. Observation points LL4 is located northwest of B Panel, and LL5, LL6, and LL7 are located east of B, C, and A panels, respectively.

Concentrations of antimony, sulfate, and TDS in groundwater would exceed Idaho groundwater standards inside the lease boundary, but would not exceed applicable standards outside the lease boundary **(Figures 4.3-7** and **4.3-8)**. Groundwater standards for antimony are based on human health considerations. Standards for sulfate and TDS are based on aesthetic qualities. Note that concentrations of selenium, cadmium, and aluminum would not exceed groundwater standards at any location and, therefore, did not warrant having a plume map prepared. Modeled concentrations of COPCs with time are plotted on **Figure 4.3-9**.

TABLE 4.3-12
MODELED CONCENTRATIONS AT THE WATER TABLE FOR SELECTED LOCATIONS AT THE MINERAL LEASE BOUNDARY

Location	Observation Point	Year	Al (mg/L)	Sb (mg/L)	Cd (mg/L)	Mn (mg/L)	Se (mg/L)	SO_4 (mg/L)	TDS (mg/L)
Southwest of A Panel Backfill	LL1	100	0.01	0.0010	0.0003	0.020	0.001	20	291
		200	0.01	0.0010	0.0003	0.025	0.001	22	408
		300	0.01	0.0010	0.0003	0.0282	0.001	23	422
		400	0.01	0.0010	0.0003	0.029	0.001	23	426
		500	0.01	0.0010	0.0003	0.029	0.001	23	373
Southwest of C Panel Partial Backfill	LL2	100	0.01	0.0016	0.0003	0.029	0.001	24	286
		200	0.01	0.0016	0.0003	0.030	0.001	25	285
		300	0.01	0.0016	0.0003	0.030	0.001	25	289
		400	0.01	0.0017	0.0003	0.030	0.001	25	285
		500	0.01	0.0016	0.0003	0.029	0.001	24	289
Southwest of A Panel Backfill	LL3	100	0.01	0.0015	0.0007	**0.260**	0.001	112	408
		200	0.01	0.0017	0.0008	**0.354**	0.001	149	**649**
		300	0.01	0.0017	0.0008	**0.356**	0.001	149	**660**
		400	0.01	0.0017	0.0008	**0.350**	0.001	147	**661**
		500	0.01	0.002316	0.0007	**0.338**	0.001	105	**509**
Northwest of B Panel Backfill	LL4	100	0.01	0.0010	0.0003	0.020	0.001	20	281
		200	0.01	0.0010	0.0003	0.029	0.001	24	291
		300	0.01	0.00110	0.0003	0.030	0.001	24	296
		400	0.01	0.0010	0.0003	0.029	0.001	24	297
		500	0.01	0.0010	0.0003	0.029	0.001	23	291
Northeast of B Panel Backfill	LL5	100	0.01	0.0023	0.0003	0.045	0.001	31	281
		200	0.01	0.0041	0.00044	**0.154**	0.001	76	284
		300	0.01	0.0043	0.0004	**0.158**	0.001	77	283
		400	0.01	0.0042	0.0004	**0.156**	0.001	76	283
		500	0.01	0.0044	0.0004	**0.159**	0.001	68	286
Northeast of C Panel Partial Backfill	LL6	100	0.01	0.0035	0.0003	**0.058**	0.001	38	285
		200	0.01	0.0039	0.0003	**0.063**	0.001	41	287
		300	0.01	0.0039	0.0003	**0.065**	0.001	41	289
		400	0.01	0.0040	0.0003	**0.067**	0.001	42	288
		500	0.01	0.0040	0.0003	**0.068**	0.001	43	288
Northeast of A Panel Backfill	LL7	100	0.01	0.0010	0.0003	0.023	0.001	21	287
		200	0.01	0.0011	0.0004	**0.081**	0.001	43	294
		300	0.01	0.0013	0.0006	**0.081**	0.001	86	298
		400	0.01	0.0015	0.0007	**0.191**	0.001	114	296
		500	0.01	0.0016	0.0007	**0.264**	0.001	126	290
Idaho Groundwater Standard			0.2	0.006	0.005	0.05	0.05	250	500

Bolded values exceed Idaho groundwater standards contained in IDAPA 58.01.11

Figure 4.3-7 Constituent Concentrations at the Water Table 500 Years After Mining

Figure 4.3-8 Constituent Concentrations at the Water Table 500 Years After Mining

Figure 4.3-9 Modeled Concentrations Over Time, Based on Proposed Action

Results of the model indicate that the plume of manganese would extend about 3,000 feet northwest of the lease boundary and that the concentration of manganese would exceed the applicable aesthetic-based secondary standard for groundwater of 0.05 mg/L. The plume would originate from the backfilled Panels A and B and also from the partially backfilled Panel C **(Figure 4.3-7)**. The plume of manganese would reach its maximum size about 400 years after mining ends and then decrease slightly in later years. Two wells in the area (2 miles and 2.5 miles west of Rasmussen Ridge) provide domestic water. The manganese plume is not expected to reach these wells nor does manganese pose a threat to human health. At the farthest extent of the manganese plume, the depth to groundwater in the Wells Formation is greater than 2000 feet, which would limit the availability of groundwater for human use.

Modeled plumes for sulfate and TDS would reach maximum size and concentration between 200 and 400 years after mining ends, but concentrations would not exceed groundwater standards outside the lease boundary. The plume of antimony would be confined to a small area below the partially backfilled Panel A inside the lease boundary and would not extend outside the footprint of the pit.

The IDEQ requires that groundwater quality cannot be contaminated outside the lease boundary of a phosphate mine under the Idaho Non-degradation standards. This is why observation points were established in the model to correspond with the lease boundary. It is of note that background water quality in the Wells Formation in the project area is not well known and some constituents may naturally exceed numerical groundwater standards. In particular, naturally occurring manganese concentrations of up to 1.1 mg/L have been observed in Wells Formation groundwater at the Dry Valley Mine (Whetstone 2002).

4.3.1.5 Alternative 1 – Proposed Action with Impermeable Capping of Backfilled Area

This alternative involves capping the backfilled overburden with a layer of low permeability material between the seleniferous waste rock and the applied growth media, in order to reduce potential effects of water infiltrating into the backfill, as described in Section 2.3.

To assess potential impacts, infiltration through the partially and fully backfilled panels was evaluated using the EPA HELP3 model for both the clay cap and the synthetic liner cap. Model results indicate that the area-weighted average infiltration for the fully backfilled panels would be 0.362 for the clay cap and 0.198 inches per year for the synthetic liner cap. In neither case is the partially backfilled pit capped, and the resulting infiltration rate is 90.1 and 90.2 inches per year for the two cap designs. These results are shown in **Table 4.3-13**.

TABLE 4.3-13
WATER BALANCE RESULTS OF HELP INFILTRATION MODELING FOR THE CLAY CAP AND SYNTHETIC LINER CAP ALTERNATIVES (IN INCHES/YEAR)

Alternative	Zone	Precipitation Run-on	Runoff	Evapo-transpiration	Lateral Drainage	Infiltration
Clay Cap	NR Backfill Area A	26.84	11.97	14.50	0.04	0.323
Clay Cap	NR Backfill Area B	33.65	18.37	14.73	0.06	0.491
Clay Cap	NR Backfill Area C1	26.84	11.97	14.50	0.05	0.319
Clay Cap	NR Backfill Area C2	26.84	11.96	14.51	0.02	0.353
Clay Cap	NR Backfill Area ED1	26.84	11.97	14.50	0.02	0.345
Clay Cap	NR Backfill Area ED2	31.20	15.37	15.27	0.13	0.436
Clay Cap	NR Backfill Area C3	110.96	0.00	20.87	N/A	90.09
Synthetic Liner Cap	NR Backfill Area A	26.84	11.97	14.50	0.19	0.174
Synthetic Liner Cap	NR Backfill Area B	33.65	18.37	14.73	0.30	0.257
Synthetic Liner Cap	NR Backfill Area C1	26.84	11.97	14.50	0.20	0.170
Synthetic Liner Cap	NR Backfill Area C2	26.84	11.96	14.51	0.12	0.248
Synthetic Liner Cap	NR Backfill Area ED1	26.84	11.97	14.50	0.13	0.233
Synthetic Liner Cap	NR Backfill Area ED2	31.22	15.38	15.28	0.37	0.192
Synthetic Liner Cap	NR Backfill Area C3	111.09	0.00	20.89	N/A	90.20

At these predicted infiltration rates, modeling indicates it would take 119 years for seepage from the clay-capped fully backfilled pit to infiltrate through the approximately 400 feet of unsaturated rock to the underlying regional aquifer, and 218 years for seepage from the synthetic liner capped pit to reach the water table. Seepage from the partially backfilled panel would arrive at the water table in about 3.2 years.

Surface Water Impacts

Flow Impacts. Impacts to surface water flow during mining would be identical to the Proposed Action. After mining, surface water flow would be affected by intercepted runoff in the partially backfilled pit and increased runoff and lateral drainage from the low-permeability cap. Although these effects have not been fully quantified, the result would most likely be a small increase in surface water flow into Reese Canyon Creek and No Name Creek and a decrease in flow in the West Fork of Sheep Creek. The decrease in flow in West Fork of Sheep Creek would be slightly smaller than under the Proposed Action, since the size of the partially backfilled pit would be essentially the same and the portion of the fully backfilled pit would provide more runoff and lateral drainage from the cap than in the Proposed Action.

Water Quality Impacts. The backfilled pits would not affect the quality of surface water runoff, if capped with clay or synthetic liner. No surface seeps would occur, because the overburden is placed below the original ground surface and the cap would prevent most of the water from infiltrating into the backfill. The engineered cover would prevent surface water runoff from contacting reactive materials in the backfill, and chemical impacts to surface water runoff and lateral drainage would not occur.

Groundwater Impacts

Alluvium and Rex Chert. The reduction of flow in the alluvium would be slightly greater than in the Proposed Action, because the low-permeability cap would prevent water from recharging the alluvium and Rex Chert on the northeast margin (hanging wall) of the pit. However, since only 0.02 and 0.05 inches/year of seepage from the backfilled panels are expected to enter the alluvium and Rex Chert in the Proposed Action case, the difference between the Capping Alternative and the Proposed Action is minimal with respect to flow impacts in the alluvium and Rex Chert.

There would be no substantial impact to groundwater quality in the alluvium and Rex Chert, under the Capping Alternative. The low-permeability cap would reduce or limit leachate from seeping into groundwater.

Wells Formation. Impacts to flow in the Wells Formation regional aquifer would be less under the Capping Alternative than under the Proposed Action. Infiltration through the partially backfilled pit (90.1 and 90.2 inches/year) would be slightly higher than for the Proposed Action (88.45 inches/year). Infiltration through the fully backfilled panels would be reduced from 0.83 inches/year for the Proposed Action to 0.36 inches/year for the clay cap or 0.19 inches/year for the synthetic liner cap. The total increase in recharge to the Wells Formation aquifer would be higher for the Proposed Action (336%) than for the clay cap (331%) or the synthetic liner (328%), as shown in **Table 4.3-14**.

TABLE 4.3-14
COMPARISON OF FLOW IMPACTS TO WELLS FORMATION IN THE CLAY CAP AND SYNTHETIC LINER CAP ALTERNATIVE VS. THE PROPOSED ACTION

Alternative	Increase in Recharge to Wells Formation Aquifer	Height of Mound in Wells Formation Aquifer
Proposed Action	336%	Approx 15 ft
Clay Cap Alternative	331%	Approx 15 ft
Synthetic Liner Cap Alternative	328%	Approx 15 ft

Impacts to water quality in the Wells Formation regional aquifer would decrease under the Impermeable Cap Alternative. As in the Proposed Action, seepage that infiltrates through the backfill would carry solutes downward through the unsaturated zone into the aquifer. However, infiltration rates from the fully backfilled panels would be lower than for the Proposed Action, and chemical mass loading would therefore be less.

Modeled concentrations for COPCs in the regional groundwater aquifer for the clay cap alternative were calculated using the MT3DMS transport model at the lease boundary for seven observation points (LL1-LL7) at 100, 200, 300, 400, and 500 years after the end of mining (**Table 4.3-15**). Results indicate that manganese would form a plume in groundwater that exceeds secondary drinking water standards at the lease boundary and would extend outside of the lease boundary northwest from the pit (**Figure 4.3-10**). Secondary drinking water standards are guidelines regulating contaminants that may cause cosmetic effects (staining) or aesthetic effects (taste, odor, color) in drinking water, but which do not affect human health. The manganese plume would reach its maximum size about 220 years after the end of mining and decrease slightly in size in following years. Concentrations of antimony, sulfate and TDS in groundwater, would be above Idaho groundwater standards inside of the lease boundary, but would not exceed applicable standards outside of the lease boundary (**Figure 4.3-11**). Concentrations of selenium, cadmium, and aluminum would not exceed groundwater standards at any location. Modeled COPC concentrations with time are plotted in **Figure 4.3-12**.

Concentrations of COPCs in the regional groundwater aquifer for the synthetic liner cap alternative were modeled similarly. The results indicated that concentrations of all modeled constituents would be lower for the synthetic cap alternative than for the clay cap or the Proposed Action (**Table 4.3-16**). Concentrations of antimony, sulfate and TDS would not exceed applicable standards outside of the lease boundary (**Figure 4.3-13**). Manganese is the only constituent that would exceed applicable groundwater standards at and beyond the mineral lease boundary. The manganese plume in groundwater is shown in **Figure 4.3-14**. Modeled COPC concentrations with time are plotted in **Figure 4.3-15**.

Infiltration would be reduced by a low-permeability cap system using compacted clay or an impervious synthetic liner. These liner systems would have a finite life span of 50 to 100 years, beyond which time the liner would degrade and its effectiveness be reduced. Low-permeability caps would have environmental impacts quite similar to the Proposed Action. However, a compacted clay cap would cost approximately $9.5 million more than the Proposed Action, and a synthetic liner approximately $20.7 million more than the Proposed Action.

4.3.1.6 Alternative 2 - No-Action

The No Action Alternative would result in the elimination of water resources impacts described in this section of the EIS associated with the Proposed Action. Specifically, the reduction in surface water runoff to Reese Canyon Creek, No Name Creek, and Sheep Creek would not occur. Flow in the alluvium would not be reduced, and a groundwater mound would not form in the Wells Formation regional aquifer. Chemical loading to the Wells Formation aquifer, alluvium, and Rex Chert from the pit backfill would not occur. However, impacts to water resources from previous and existing operations at Central and South Rasmussen Ridge Mine would still be present.

TABLE 4.3-15
MODELED CONCENTRATIONS AT THE WATER TABLE AT SELECTED LOCATIONS AT THE MINERAL LEASE BOUNDARY FOR THE CLAY CAP ALTERNATIVE

Location	Observation Point	Year	Al (mg/l)	Sb (mg/l)	Cd (mg/l)	Mn (mg/l)	Se (mg/l)	SO4 (mg/l)	TDS (mg/l)
Southwest of A Panel Backfill	LL1	100	0.01	0.0010	0.0003	0.020	0.001	20	281
		200	0.01	0.0010	0.0003	0.020	0.001	20	284
		300	0.01	0.0010	0.0003	0.021	0.001	20	282
		400	0.01	0.0010	0.0003	0.021	0.001	20	283
		500	0.01	0.0010	0.0003	0.022	0.001	21	284
Southwest of C Panel Partial Backfill	LL2	100	0.01	0.0017	0.0003	0.030	0.001	25	284
		200	0.01	0.0017	0.0003	0.030	0.001	25	284
		300	0.01	0.0017	0.0003	0.030	0.001	25	282
		400	0.01	0.0017	0.0003	0.030	0.001	25	285
		500	0.01	0.0017	0.0003	0.030	0.001	25	284
Southwest of A Panel Backfill	LL3	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0014	0.0006	**0.185**	0.001	84	367
		300	0.01	0.0014	0.0005	**0.183**	0.001	83	360
		400	0.01	0.0014	0.0005	**0.185**	0.001	84	365
		500	0.01	0.0014	0.0005	**0.187**	0.001	85	367
Northwest of B Panel Backfill	LL4	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0010	0.0003	0.024	0.001	22	286
		300	0.01	0.0010	0.0003	0.024	0.001	21	281
		400	0.01	0.0010	0.0003	0.024	0.001	22	283
		500	0.01	0.0010	0.0003	0.024	0.001	22	283
Northeast of B Panel Backfill	LL5	100	0.01	0.0024	0.0003	0.043	0.001	30	288
		200	0.01	0.0040	0.0003	**0.099**	0.001	54	302
		300	0.01	0.0042	0.0003	**0.108**	0.001	58	306
		400	0.01	0.0044	0.0003	**0.112**	0.001	60	318
		500	0.01	0.0041	0.0003	**0.106**	0.001	57	298
Northeast of C Panel Partial Backfill	LL6	100	0.01	0.0036	0.0003	**0.059**	0.001	38	289
		200	0.01	0.0040	0.0003	**0.064**	0.001	41	291
		300	0.01	0.0039	0.0003	**0.064**	0.001	41	287
		400	0.01	0.0040	0.0003	**0.065**	0.001	41	290
		500	0.01	0.0039	0.0003	**0.065**	0.001	41	289
Northeast of A Panel Backfill	LL7	100	0.01	0.0010	0.0003	0.020	0.001	20	286
		200	0.01	0.0010	0.0004	**0.025**	0.001	22	281
		300	0.01	0.0011	0.0005	**0.066**	0.001	38	301
		400	0.01	0.0012	0.0005	**0.127**	0.001	62	343
		500	0.01	0.0013	0.0005	**0.153**	0.001	71	348
Idaho Groundwater Standard			0.2	0.006	0.005	0.05	0.05	250	500

Figure 4.3-10 **Plume Boundaries at the Water Table for the Clay Cap Alternative**

Figure 4.3-11 Plume Boundaries at the Clay Cap Alternative

Figure 4.3-12 Model Results Showing Concentrations Over Time, Based on the Clay Cap Alternative

TABLE 4.3-16
MODELED CONCENTRATIONS AT THE WATER TABLE AT SELECTED LOCATIONS AT THE MINERAL LEASE BOUNDARY FOR THE SYNTHETIC LINER CAP ALTERNATIVE

Location	Observation Point	Year	Al (mg/l)	Sb (mg/l)	Cd (mg/l)	Mn (mg/l)	Se (mg/l)	SO4 (mg/l)	TDS (mg/l)
Southwest of A Panel Backfill	LL1	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0010	0.0003	0.020	0.001	20	282
		300	0.01	0.0010	0.0003	0.020	0.001	20	281
		400	0.01	0.0010	0.0003	0.021	0.001	20	283
		500	0.01	0.0010	0.0003	0.021	0.001	21	285
Southwest of C Panel Partial Backfill	LL2	100	0.01	0.0017	0.0003	0.030	0.001	25	285
		200	0.01	0.0017	0.0003	0.031	0.001	25	283
		300	0.01	0.0017	0.0003	0.030	0.001	25	286
		400	0.01	0.0017	0.0003	0.030	0.001	25	283
		500	0.01	0.0017	0.0003	0.030	0.001	25	283
Southwest of A Panel Backfill	LL3	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0010	0.0003	0.020	0.001	20	280
		300	0.01	0.0014	0.0005	**0.185**	0.001	84	365
		400	0.01	0.0014	0.0005	**0.183**	0.001	83	362
		500	0.01	0.0014	0.0005	**0.184**	0.001	83	363
Northwest of B Panel Backfill	LL4	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0010	0.0003	0.020	0.001	20	285
		300	0.01	0.0010	0.0003	0.024	0.001	21	283
		400	0.01	0.0010	0.0003	0.024	0.001	22	285
		500	0.01	0.0010	0.0003	0.025	0.001	22	286
Northeast of B Panel Backfill	LL5	100	0.01	0.0024	0.0003	0.043	0.001	30	288
		200	0.01	0.0039	0.0003	**0.063**	0.001	40	293
		300	0.01	0.0041	0.0003	**0.100**	0.001	54	296
		400	0.01	0.0044	0.0003	**0.110**	0.001	59	313
		500	0.01	0.0045	0.0003	**0.115**	0.001	62	321
Northeast of C Panel Partial Backfill	LL6	100	0.01	0.0036	0.0003	**0.060**	0.001	39	292
		200	0.01	0.0040	0.0003	**0.064**	0.001	41	290
		300	0.01	0.0040	0.0003	**0.064**	0.001	41	289
		400	0.01	0.0040	0.0003	**0.064**	0.001	41	289
		500	0.01	0.0040	0.0003	**0.066**	0.001	42	294
Northeast of A Panel Backfill	LL7	100	0.01	0.0010	0.0003	0.020	0.001	20	282
		200	0.01	0.0010	0.0003	0.020	0.001	20	285
		300	0.01	0.0010	0.0003	0.025	0.001	22	280
		400	0.01	0.0011	0.0004	**0.069**	0.001	39	304
		500	0.01	0.0013	0.0005	**0.132**	0.001	64	350
Idaho Groundwater Standard			0.2	0.006	0.005	0.05	0.05	250	500

Figure 4.3-13 Plume Boundaries at the Water Table for the Synthetic Liner Cap Alternative

Figure 4.3-14 Plume Boundaries at the Water Table for the Synthetic Liner Cap Alternative

Figure 4.3-15 Model Results Showing Concentrations Over Time, Based on the Synthetic Liner Cap

4.3.2 Irreversible and Irretrievable Commitment of Resources

Irreversible impacts to water resources from the Proposed Action would include capture of surface water runoff and shallow alluvial groundwater by the partially backfilled panel, and changes in groundwater level in the Wells Formation.

Flow in Reese Canyon Creek, No Name Creek and West Fork of Sheep Creek drainages would be decreased by capture of surface water runoff by the partially backfilled pit. Runoff into Reese Canyon Creek above the Little Blackfoot River would decrease by 4 percent. Runoff into No Name Creek above its intermittent western tributary would decrease by 3 percent, and runoff into West Fork of Sheep Creek above the confluence with Sheep Creek would decrease by 37 percent. This would be an irreversible commitment of water resources, as surface water runoff would be converted to infiltration to groundwater.

Groundwater flow in intermittently saturated alluvium would be intercepted by the mine pits. Alluvial groundwater flow in Reese Canyon above the confluence with the Little Blackfoot River would decrease by about 31 percent. Alluvial groundwater flow in No Name Creek would decrease by about 10 percent, and alluvial groundwater flow in West Fork of Sheep Creek would decrease by 37 percent.

Capture of surface water runoff and alluvial groundwater by the mine pits would reduce the amount of water available to wetland areas and springs in Reese Canyon and West Fork of Sheep Creek.

Recharge to the Wells Formation would be increased by the capture of surface water and shallow alluvial groundwater by the partially backfilled pit. Deep groundwater levels would increase by about 15 feet in the area of the mine.

4.3.3 Residual Impacts

Overburden placed as backfill in the pit panels would continue to leach metals into the environment. The leachate would affect water quality in the Wells Formation regional aquifer and, to a lesser extent, in the alluvium and Rex Chert. Changes to groundwater quality in the Wells Formation aquifer would include increased total dissolved solids concentration, primarily in the form of manganese, antimony, and sulfate. Over an unknown period of time, concentrations of metals in seepage from the backfill would decline toward a steady-state water chemistry.

4.3.4 Mitigation Summary

Project design features, BMPs, and the proposed Reclamation Plan (see Chapter 2) are the elements of the Proposed Action designed to reduce environmental impacts to water resources. No mitigation measures have been identified to reduce anticipated impacts.

4.4 WATERSHED AND SOILS

4.4.1 Direct and Indirect Impacts on Soils

Impacts to soil resources would occur from physical and chemical changes during mining when salvaged soil is mixed, stockpiled, and stabilized in the growth media storage area. Other direct impacts would occur from residual loss of soil as a result of excavation, movement to stockpiles, redistribution on the backfilled areas, and completion of reclamation. Soil erosion and handling would have potential effects on soil fertility and final success of revegetation. Agrium anticipates salvaging 1,015,716 cu yd of growth media to provide 2 to 3 feet of cover for revegetation.

4.4.1.1 Proposed Action

Physical Impacts

The Proposed Action would result in 269 acres of disturbance, of which 197 acres would be reclaimed. Direct impacts to soil from the Proposed Action would include changes in the physical and chemical characteristics to the parent soil, including mobilization of selenium and some loss to wind and water erosion. Another direct effect of the Proposed Action would be erosion of the growth media after it is redistributed during reclamation. Until the soil is stabilized by successful vegetative growth, wind and water erosion would have greater potential. When revegetation is successful, erosion potential would be substantially reduced.

Mixing the salvaged topsoil and growth media material during recovery and replacement changes the characteristics of the parent soil. Soil forms over time, so that it is not feasible to return disturbed land to previous conditions through reclamation. Despite the loss of characteristics in the parent soil, a suitable growth media base could be placed to create successful seedbed for vegetation establishment. The soil types that would be suitable for use as growth media are presented in **Table 3.4-1**. Direct impacts to soil resources also include compaction of the growth media by equipment during salvage, stockpiling, and replacement. Effects from topsoil compaction include reduced permeability, decreased available water holding capacity, and loss of soil structure.

Salvaging topsoil during open-pit mining operations would remove vegetative cover and disturb soil structure. Conditions that would be present during soil salvage and that would make the potential for water erosion high are soil surface conditions, steep slopes, and the potential for heavy thunderstorms in the summer. Soil loss through water erosion would have the greatest potential to occur during soil salvaging, while a cover crop is established on growth media stockpiles, and during the period between redistribution of the growth media and successful revegetation. Soil losses caused by water erosion would be controlled and reduced with timely establishment of vegetative cover on stockpiles of the growth media and implementation of BMPs and concurrent reclamation practices outlined in the North Rasmussen Ridge Mine and Reclamation Plan.

Wind erosion hazard of stockpiled topsoil is expected to be low given that there are only two soil complexes that exhibit a high wind erosion potential (WEG of 3). These soil types are C and D, which are alluvial soils found on stream terraces and flood plains in all three creeks in the disturbance area. No D complex soils would be disturbed by any project activities. Timely revegetation of reclaimed disturbed areas concurrent with salvage would reduce the potential for soil erosion by improving vegetative ground cover while mining operations continue on to subsequent areas.

The expected relative amount of erosion would be a function of the total area disturbed at any time and the length of time of the disturbance. Based on Agrium's mine sequence for Panels A and B and the plan to reclaim disturbed areas through concurrent backfill and salvage, 30 acres of land would be disturbed by construction of the mine pit at any time during the mine sequence. Backfill slopes would be shaped under the Proposed Action to a final 3.0h:1.0v slope, reducing steep areas and thus decreasing erosion potential caused by steep slopes. At closure, all erosion from the unreclaimed pit walls would reside on the pit floor.

Biological Impacts

Biological and chemical modifications to the soil would occur when topsoil mixes with subsoil during salvage and stockpiling, thereby changing the physical and chemical characteristics and soil productivity of what would eventually serve as the growth media during reclamation. Potential soil productivity of the stockpiled growth media would be affected by mixing of the topsoil and subsoil during salvage and movement to the temporary growth media storage area. Mixing of topsoil and subsoil would be minimized by direct placement of these materials on reclaimed areas. Minimizing mixing enhances the success rate of residual native seeds and rhizomes. These biological elements along with bacterial and fungal strands would be destroyed by prolonged storage. Total loss of productivity would occur in the 72 acres of pit walls that are not reclaimed.

Chemical Impacts and Mobilization of Selenium

Soil structure would be altered during salvaging and redistribution, which could oxidize selenium in the soil and mobilize it in the surface environment. Mobilization would result in increased availability of selenium and other trace metal elements for uptake by vegetation. The availability of selenium for plant uptake would depend on the presence or absence of soluble forms of selenium. Increased amounts of soluble selenium in the growth media could increase the selenium content of vegetation on reclaimed areas. During salvage and redistribution, selenium in subsurface soil can be exposed to the environment, increasing the potential for oxidation processes that increase the amount of soluble selenium. Soluble selenium in the growth media is mobile and subject to bioaccumulation in plants and leaching out of the growth media to surface run-off or infiltration (BLM 2001). The effects of concentrations of soluble selenium on vegetation, livestock, fisheries, and other wildlife are described in more detail in Sections 4.5, 4.6, 4.7, and 4.9.

Indirect chemical impacts caused by disturbance of soil from the Proposed Action include changes in water quality as a result of sedimentation from the erosion of exposed slopes.

Physical and chemical changes caused by disturbance to the soil structure, soil loss, reduced fertility, and reduced biological functions could result in decreased productivity of vegetative cover. The implementation of BMPs, as discussed in the North Rasmussen Ridge Supplemental Mine and Reclamation Plan (Agrium 2001), as well as concurrent salvage and backfilling and use of stockpiled topsoil, would minimize the indirect impacts to other resources from erosion and changes in characteristics of the soil. The BMPs would minimize erosion and minimize soil loss from the site thereby retaining the chemical and biological components of the soils on site, even if in a disturbed state.

4.4.1.2 Alternative 1 - Proposed Action with Impermeable Capping of Backfilled Area

The direct and indirect impacts under Alternative 1 would be similar to the Proposed Action except for the number of acres of soil disturbed. However, Alternative 1 would involve construction of a layer of impermeable material, clay or synthetic, between the seleniferous waste rock and the applied growth media. This impermeable layer would limit or reduce the potential effects of water that infiltrates into the backfill. Both types of impermeable cap would require a layer of screened limestone below the growth media to act as a natural drain for run-off water from the pit backfill area. Additional disturbance likely would be required under Alternative 1 for a surface mining operation and mine roads needed to supply clay material for the impermeable cap. The acreage affected by this new disturbance has not been quantified, but likely would be about 25 acres. Use of clay for the impermeable cap would require mining clay from land privately owned by Agrium. Use of a synthetic material for the impermeable cap would increase the cost of implementing Alternative 1 substantially; however, an external clay mine would not be required. A clay layer is estimated to cost approximately $9.5 million more than the Proposed Action, and a synthetic layer approximately $20.7 million more than the Proposed Action.

Construction of this impermeable layer would require shallower backfill slopes than the proposed 3.0h:1.0v slope to avoid slope failure. This layer therefore would require an external waste rock dump outside of the pit perimeter to contain the extra volume of waste rock that could not be backfilled. The total area of disturbance outside the perimeter of the pit for the external waste rock dump would increase by 26 acres. Land for the external overburden dump would likely include forested lands and other habitats, both on and off the leases. Additional miscellaneous operations required for the external waste rock dumps would include purchase of timber, pre-stripping and hauling of slash and growth media, and water management and silt retention structures for erosion control. Additional impacts to soil and watershed resources would occur as a result of these miscellaneous operations. The general direct impacts to soils and watershed resources would include increased erosion potential caused by removal of vegetation, loss of soil from increased movement of growth media and slash, and some damage to the structure of the soil from construction of the silt retention structures (although the structures themselves would substantially mitigate potential loss of soil). Indirect impacts would include potential sedimentation in various streams within the watersheds.

4.4.1.3 Alternative 2 – No Action

The No Action Alternative would preclude mining in the North Rasmussen Ridge area. The No Action Alternative would involve continued mining at the Central Rasmussen Ridge mine until all ore was recovered. Approximately 231 acres would ultimately be disturbed, with 196 acres, or 85 percent of the disturbed area, reclaimed after ore recovery is complete. The final 35 acre portion of the Central Rasmussen Ridge Mine pit would not be backfilled, but would remain in an unreclaimed state as per the approved mine plan. The open pit would lead to potential direct effects to soils and watershed resources in the project area from wind and water erosion.

4.4.2 Direct and Indirect Impacts on Watersheds

Impacts to watersheds would occur from the project through disturbance to soils and vegetation and alterations to topography. Other factors could also affect watershed conditions including wildfire, fire suppression, fishing, livestock grazing, road construction, and timber harvesting.

4.4.2.1 Proposed Action

Disturbances from the Proposed Action would affect the vegetative community and the erosion process on the site, and the hydrology and water quality of receiving streams. Hillslope erosion has been the major erosion force in the area watersheds (Maxim 2002e). Sediment produced by erosion has already indirectly influenced stream channel condition and water quality via increased erosive force and channel deposition in the Angus Creek and Sheep Creek subwatersheds where the project is located. Since 1982, stormwater control measures (BMPs) at mines in the subwatersheds have been implemented to minimize the impacts of erosion. Mining impacts have been minimal in the Sheep Creek drainage (Maxim 2002e). Potential impacts from the Proposed Action on the Angus Creek and Sheep Creek subwatersheds are expected to be minimal in that the Proposed Action only would disturb approximately 1.4 percent of the area in the two watersheds.

4.4.2.2 Alternative 1 – Proposed Action with Impermeable Capping of Backfilled Area

The direct and indirect impacts under Alternative 1 would be similar to the Proposed Action except for the amount of disturbed area. Alternative 1, using a compacted clay layer for the low-permeability cap, would disturb additional area for an external waste rock dump (26 acres) and a clay quarry (25 acres). If a synthetic membrane is used, the alternative would only disturb the 26 acres for the external waste rock dump. In both cases, all areas would be reclaimed except for the pit walls. The additional disturbance proposed for Alternative 1 would occur in the Angus Creek subwatershed, which is considered the most heavily affected subwatershed in the study area (Maxim 2002e).